

# PATENT ABSTRACTS OF JAPAN

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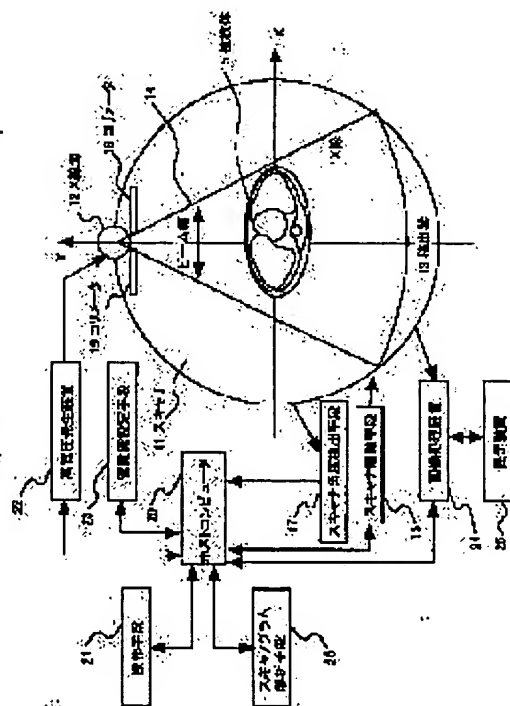
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## (54) RADIOGRAPHIC TOMOGRAPH

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a radiographic tomograph capable of irradiating a suitable X-ray dose by suppressing a useless X-ray exposure to a specimen.

**SOLUTION:** The radiographic tomograph comprises an X-ray source 12, a detector 13, a scanner 11 mounting them, a high-voltage generator 22, a host computer 20, an image processing unit 24, a display unit 25 and the like. The tomograph further comprises an operating means 21 for setting scanning conditions of the tomograph, a scanogram analyzing means 26 for analyzing scanogram image data of the specimen 15 to generate a three-dimensional transmission length model of the specimen, a duct current setting means 23 for automatically setting a change pattern of an intraduct current (hereinafter referred to as a 'duct current') in response to a photographing site of the specimen 15 based on the transmission length model of the specimen and the scanning conditions, and a dose calculating means for calculating a dose to be irradiated to the specimen 15 based on the change pattern of the duct current to display a calculated result on the unit 25.



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**DESCRIPTION OF DRAWINGS**

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**[Brief Description of the Drawings]**

- [Drawing 1] The block diagram showing the whole X-ray CT scanner configuration concerning this invention.
- [Drawing 2] The important section component of the X-ray CT scanner concerning this invention.
- [Drawing 3] The flow chart of a series of actuation of the 1st example of scan operation which used the X-ray CT scanner concerning this invention.
- [Drawing 4] Drawing showing correspondence with a SUKAYANO gram image, a slice location, and the example of projection data.
- [Drawing 5] Drawing showing the model in 1 slice location of a three-dimension-radiopacity length model.
- [Drawing 6] The radiopacity length model in the slice location Z.
- [Drawing 7] The example of a display of the change pattern of the tube electric current.
- [Drawing 8] The example of the change pattern of the tube electric current.
- [Drawing 9] The flow chart of a series of actuation of the 2nd example of scan operation which used the X-ray CT scanner concerning this invention.
- [Drawing 10] The example of a display of the count result of the dose distribution in analyte.
- [Drawing 11] Drawing for explaining the creation procedure of an analyte CT valve model.
- [Drawing 12] Drawing for explaining the procedure of exposure X dose distribution count.
- [Drawing 13] What superimposed and displayed the change pattern of the tube electric current on the SUKAYANO gram image of analyte.
- [Drawing 14] Drawing having shown the relation between the tube electric current and the thickness of analyte.

**[Description of Notations]**

- 10 -- Gantry
- 11 -- CT scanner (scanner)
- 12 -- X line source
- 13 -- X-ray detector (detector)
- 14 -- X-ray beam (X-ray)
- 15 -- Analyte
- 16 -- Scanner driving means
- 17 -- Scanner include-angle detection means
- 18 -- Table
- 19 -- Collimator
- 20 -- Host computer
- 21 -- Actuation means
- 22 -- High-voltage transformer assembly
- 23 -- Tube electric current setting means
- 24 -- Image processing system
- 25 -- Display
- 26 -- SUKAYANO gram analysis means
- 29 29a -- SUKAYANO gram image
- 30 -- Radiopacity length model (ellipse form model)

31, 31a, 31b, 31c, 31d, 47a, 47b -- Change pattern of the tube electric current  
35 -- Analyte cross section  
36 -- Analyte side face  
38a, 38b, 38c, 39a, 39b, 39c, 39d, 46a, 46b, 46c -- Isodose lines  
41 -- Standard body CT valve model data  
42 -- Count SUKYANO gram image data  
43 -- Observation SUKYANO gram image data  
44 -- Analyte CT valve model data  
45 -- Analyte mu model data  
51, 52, 53 -- Graph

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[Translation done.]

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the X-ray CT scanner which is applied to the X-ray CT scanner which controls the X-ray tube current under photography (it is hereafter called the tube electric current for short), and controls the exposed dose of analyte, especially can reset the change curve of the tube electric current under photography in consideration of the exposed dose and image quality of analyte.

[0002]

[Description of the Prior Art] The conventional X-ray CT scanner is made to take a photograph in the same tomographic layer by being the same CAT (it being hereafter called scan for short) conditions (voltage of X-ray tube (it being hereafter called tube voltage for short), tube electric currents, etc.). Moreover, although the helical scan which scans analyte spirally and photos it in recent years is used increasingly widely, the scanning conditions of the direction of a body axis are also regularity during a scan.

[0003] It followed, for example, since the transparency length of the X-ray in analyte changed with the angle-of-rotation locations of X line source a lot to the revolving shaft of a CT scanner (it is hereafter called a scanner for short) when it is not a concentric circle but an ellipse, the cross section of analyte had the trouble which the excess and deficiency of X dosage penetrated in the same tomographic layer generate.

[0004] Moreover, in the organ of a low consistency of thoraxs, such as lungs, and the organ of the high density of abdomens, such as liver, since the absorption coefficients of an X-ray differed greatly, when scanning from a thorax continuously to an epigastric region and X dosage which is suitable for lungs was set up, it ran short in liver, and when X dosage which is suitable for liver was set up, the situation which becomes superfluous had arisen in lungs.

[0005] When X dosage to penetrate runs short, S/N (SN ratio) gets worse by reduction of X linear-light child's amount detected by the X-ray detector (it is hereafter called a detector for short), and S/N of the whole fault image obtained by image reconstruction as a result gets worse. On the contrary, when there is too much X dosage to penetrate, the invalid X-ray exposure will be made to analyte.

[0006] The approach of controlling the tube voltage indicated by JP,53-110495,A as an approach of solving these troubles and the approach of controlling the tube electric current indicated by JP,9-108209,A and JP,10-309271,A are proposed.

[0007]

[Problem(s) to be Solved by the Invention] However, in order to change tube voltage during a scan, the spectrum of an X-ray changes, and the approach of controlling the tube voltage of JP,53-110495,A has the trouble that a CT valve cannot be determined. For this reason, the approach of controlling the tube electric current is in use current.

[0008] As an approach which is going to control the tube electric current the optimal according to analyte, there is a method of determining the pattern which controls the tube electric current beforehand the approach of controlling the tube electric current using the transparency X dosage data in front of the half period of scanner rotation and based on the SUKYANO gram photoed from a different 2-way like JP,9-108209,A according to the location of analyte like JP,10-309271,A.

[0009] However, in helical scan, especially the approach using the transparency X dosage data in front of the half period of scanner rotation of JP,10-309271,A has the trouble that a gap of transparency X dosage data becomes large, when enlarging a scanning pitch. Moreover, the X-ray absorption property of analyte cannot respond like [ before and behind a

diaphragm ] in the field which changes a lot.

[0010] By performing SUKYANO gram photography twice, the approach of acquiring the SUKYANO gram from the 2-way from which JP,9-108209,A differs makes the unnecessary X-ray exposure to analyte increased, and disagrees with the purpose of reduction of the exposed dose by tube electric current control.

[0011] Moreover, while the artificers of this invention also control the tube electric current the optimal according to analyte, they have proposed law by the application for patent No. 100501 [ 2000 to ]. It is a thing about the X-ray CT scanner which invention of an application for patent No. 100501 [ 2000 to ] suppressed the unnecessary X-ray exposure to analyte, and realized low exposure-ization of analyte. The model in which the relation of the angle of rotation of a scanner and the radioparency length about analyte is shown is stored in memory. At the time of the scanning measurement to analyte, the X-ray by the setting tube electric current for every angle of rotation of the scanner which becomes settled from this model is irradiated at the same analyte, scanning measurement is performed, and a fault image is reconfigured.

[0012] In invention of an application for patent No. 100501 [ 2000 to ], it was taken into consideration neither about X dosage irradiated by analyte according to the tube electric current which emphasis was put on generation of the radioparency length model of analyte, and setting up the tube electric current based on the radioparency length of this radioparency length model, and was set as them, nor the X-ray exposure to the organ in analyte.

[0013] In consideration of the above-mentioned trouble, by this invention, the internal and external exposed dose of the analyte by the change pattern of the tube electric current automatically set up from the radioparency length model of analyte is calculated, and it aims at offering the X-ray CT scanner with which an operator can reset the change pattern of the tube electric current, taking the X-ray exposure of this analyte into consideration.

[0014]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the X-ray CT scanner of this invention X line source which carries out exposure of the X-ray while rotating the perimeter of analyte, and the X-ray detector of the many channels which detect X dosage which countered with X line source, has been arranged on both sides of analyte, and penetrated analyte, In the X-ray CT scanner possessing an image reconstruction means to reconfigure the tomogram for analyte based on X dosage data which penetrated analyte, and a display means to display a tomogram An actuation means to set up the scanning conditions of equipment, and a SUKYANO gram analysis means to analyze the SUKYANO gram image data of analyte and to generate the three-dimension-radioparency length model of analyte, A tube electric current setting means to set up automatically the change pattern of an X-ray tube current (it is hereafter called the tube electric current for short) according to the photography part of analyte based on the three-dimension-radioparency length model and the scanning conditions of said analyte, The dosage irradiated by analyte based on the change pattern of said tube electric current is calculated, and a dose calculation means to display a count result is provided (claim 1).

[0015] With this configuration, since the change pattern of the tube electric current according to the photography part of analyte is automatically set up by the tube electric current setting means based on the maximum of the tube electric current of the scanning conditions set up with the three-dimension-radioparency length model and actuation means of the analyte generated from SUKYANO gram image data by the SUKYANO gram analysis means, and the minimum value, a setup of the change pattern of the tube electric current and control of the tube electric current are automatable. Moreover, since the dosage irradiated by the analyte under scan is calculated and it is displayed on a display means by the dose calculation means, an operator can evaluate the X-ray exposure to analyte. Moreover, resetting of the change pattern of the tube electric current is possible by the evaluation result of an X-ray exposure.

[0016] In the X-ray CT scanner of this invention, further, said tube electric current setting means sets up the change pattern of said tube electric current so that the larger value of the tube electric current may be matched with the larger value of matching and said radioparency length model data for the maximum of the tube electric current set as the maximum in the photography part of the three-dimension-radioparency length model data of said analyte, and the minimum value as scanning conditions, and the minimum value. With this configuration, since the magnitude of the tube electric current which matches with the magnitude of the radioparency length of analyte and is proportional to the radiation X dosage of X line source is set up, the dosage irradiated by analyte becomes a thing corresponding to the magnitude of the radioparency length of analyte, and the dosage which penetrated the inside of analyte and analyte is equalized. Consequently, it contributes to the improvement in the image quality of CT image, and reduction of the X-ray exposure in analyte.

[0017] In the X-ray CT scanner of this invention, further, the change pattern of said tube electric current is set up so that proportionality may be held between the difference of the value of said radiopacity length model data, and the minimum value, and the difference of the set point of the tube electric current, and the minimum value between the value of the radiopacity length model data of said analyte in X line source location of arbitration, and the set point of the tube electric current. With this configuration, since there is functional relation determined with the value of gamma between the radiopacity length model data of analyte and the change pattern of the tube electric current, the change pattern of the tube electric current can be automatically set up only by setting up the maximum of the tube electric current, and the minimum value and the value of gamma, and a setup of the change pattern of the tube electric current becomes very easy.

[0018] In the X-ray CT scanner of this invention, while scanning the with-time addition value of X dosage irradiated by the analyte calculated by said dose calculation means, it displays on said display means serially. With this configuration, since the addition value of X dosage serially irradiated by analyte is displayed during a scan, an operator can grasp easily the circumstances of the amount of X-ray exposures to the analyte under scan.

[0019] In the X-ray CT scanner of this invention, further, based on the SUKAYANO gram image of the direction of a transverse plane of analyte, or the direction of a side face, said SUKAYANO gram analysis means creates the ellipse form model (two-dimensional radiopacity length model) of the radiopacity length of two or more cross sections of analyte, and generates the three-dimension-radiopacity length model of analyte by arranging this ellipse form model plurality in the direction of a body axis. With this configuration, since the three-dimension-radiopacity length model of analyte is generable by one SUKAYANO gram photography, the X-ray exposure to analyte can be reduced.

[0020] With the X-ray CT scanner of this invention, further, said ellipse form model of the radiopacity length of the cross section of analyte uses as a minor axis or a major axis the radiopacity length corresponding to the maximum X-ray magnitude of attenuation in the cross section where the SUKAYANO gram image of said analyte corresponds, and is modeled in the ellipse form which makes area the integral value which integrated with the radiopacity length corresponding to the X-ray magnitude of attenuation over the whole cross section in the direction which intersects perpendicularly with the direction of radiopacity length in said cross section. With this configuration, the ellipse form model of radiopacity length can create easily from the measurement data of the SUKAYANO gram image of analyte.

[0021] In the X-ray CT scanner of this invention, further, based on the change pattern of said tube electric current, and the three-dimension CT valve model of analyte for which it asked beforehand, the dose distribution of the inside of the body of analyte is calculated, and a dose distribution count means to display a count result is provided (claim 2). With this configuration, with a dose distribution count means, an operator can know beforehand the dose distribution in the inside of the body of the analyte by CT photography, and can judge the propriety of scanning activation in consideration of extent of an X-ray exposure of the organ to observe.

[0022] In the X-ray CT scanner of this invention, said dose distribution count means calculates the dose distribution in said analyte further based on the three-dimension  $\mu$  (linear attenuation coefficient) value model data of the analyte calculated from X dosage irradiated by the analyte which said dose calculation means calculated based on the change pattern of said tube electric current, and the three-dimension CT valve model of said analyte.

[0023] In the X-ray CT scanner of this invention, said dose distribution count means displays the graph of the dose distribution in analyte in piles to the photography part of analyte on the same screen of said display means further. Moreover, the isodose lines of dosage are displayed as a graph of the dose distribution in analyte. With this configuration, since the graph of the photography part of analyte and the dose distribution in analyte is displayed in piles on the display screen, exposed doses, such as an organ to observe, can be known at a glance, and the excess and deficiency of an X-ray exposure can be judged easily.

[0024] In the X-ray CT scanner of this invention, an analyte CT valve model generation means to generate the three-dimension-CT valve model data of analyte is provided based on the standard body CT valve model data which carried out CT photography and generated the still more standard human phantom, and the SUKAYANO gram image data of analyte. With this configuration, since it has an analyte CT valve model generation means to generate the three-dimension-CT valve model of analyte from the SUKAYANO gram image of analyte, an analyte CT valve model is generable about the analyte which has not carried out CT photography before with acquisition of 1 time of the SUKAYANO gram image data as preliminary photography.

[0025] In the X-ray CT scanner of this invention, said analyte CT valve model generation means generates the three-dimension-CT valve model of analyte further from CT image acquired by CT photography of the past of analyte. With

this configuration, since the three-dimension-CT valve model data of analyte are obtained from CT image of the past of analyte, the time amount for generation of an analyte CT valve model can be shortened by deployment of the past CT image.

[0026] In the X-ray CT scanner of this invention, further, the change pattern of the tube electric current and the SUKYANO gram image of analyte are juxtaposed on the same screen of said display means, or it displays in piles (claim 3). With this configuration, since it juxtaposes or superimposes on the SUKYANO gram image of analyte and the change pattern of the tube electric current is displayed on the same screen of a display means, an operator etc. becomes possible [ editing the change pattern of the tube electric current ], looking at the photography part of analyte, and can set up the tube electric current suitable for a photography part easily.

[0027]

[Embodiment of the Invention] Hereafter, the example of this invention is explained using an accompanying drawing. Drawing 1 is the block diagram showing the whole X-ray CT scanner configuration concerning this invention. it is shown in drawing 1 -- as -- this X-ray CT scanner -- mainly -- the X line source 12 and detector 13 grade -- carrying -- analyte 15 -- receiving -- that perimeter -- continuation -- with the gantry 10 which builds in the pivotable scanner 11. The host computer 20 which summarizes the whole equipment, and the high-voltage transformer assembly 22 which supplies the high voltage to the X line source 12, It consists of the actuation means 21 grade into which an operator inputs scanning conditions etc. as the image processing system 24 which performs pretreatment, image reconstruction processing, or various kinds of analysis processings of image data, the indicating equipment 25 which displays an image, and the table equipment 18 which carries analyte 15. In addition, since what is necessary is just to be able to rotate relatively, a scanner 11 and analyte 15 are good, though analyte 15 stands it still, a scanner 11 may rotate, a scanner 11 stands it still and the direction of analyte 15 rotates.

[0028] Drawing 2 shows the important section component of the X-ray CT scanner concerning this invention. The detail of a scanner 11 is first explained using drawing 2. In drawing 2, it is arranged by the physical relationship to which the X line source 12 and the detector 13 countered the scanner 11 180 degrees. With a collimator 19, X-ray beam 14 emitted from this X line source 12 turns into X-ray beam 14 of the shape of a fan to which the width of face and thickness of a beam were restricted, and is irradiated by analyte 15. The X line source 12 is controlled by the host computer 20 through a high-voltage transformer assembly 22. The scanner 11 whole detects angle of rotation, and based on detected angle of rotation, a host computer 20 controls the scanner driving means 16 by the scanner include-angle detection means 17, and it drives a scanner 11 with it. A detector 13 detects X-ray 14 which penetrated analyte 15, and detection data are incorporated as projection data in which the magnitude of attenuation of the X-ray by analyte 15 is shown. In an image processing system 24, after collating projection data with data, such as a scanner include angle which a host computer 20 has, and processing image reconstruction etc., it is displayed as a fault image with a display 25.

[0029] Next, important section components other than scanner 11 concerning this invention are explained. Through the scanner driving means 16, through the high-voltage transformer assembly 22, the detector 13 is indirectly connected through the image processing system 24, respectively, and direct continuation of the actuation means 21, the tube electric current setting means 22, an image processing system 24, and the SUKYANO gram analysis means 26 is carried out [ the X line source 12 ] for the scanner 11 to the host computer 20 which summarizes the whole equipment in drawing 2. A host computer 20 controls the X-ray irradiation to the analyte 15 by the X line source 12, and incorporation of the projection data (detection data) based on a detector 13 by connection between a host computer 20, and a scanner 11, the X line source 12 and a detector 13. An image processing system 24 carries out sequential reconstruction of the fault image based on the incorporated projection data according to the command of a host computer 20.

[0030] In the X-ray CT scanner concerning this invention, in order to set up scanning conditions before this scan which acquires the fault image of analyte, various housekeeping operation is performed. As this housekeeping operation, the analysis of the SUKYANO gram image data for photography of the SUKYANO gram image for positioning of analyte and a tube electric current setup, the decision of the change pattern of the tube electric current as scanning conditions, etc. are made under mediation of a host computer 20.

[0031] As main components which participate in such housekeeping operation, they are a host computer 20, the actuation means 21, the SUKYANO gram analysis means 26, the tube electric current setting means 22, the X line source 12, a detector 13, etc. in drawing 2. In this housekeeping operation, the actuation means 21 mainly inputs scanning conditions, such as the set point (maximum, minimum value) of the tube electric current, into a system first. Without rotating a scanner 11, the X line source 12 and a detector 13 photo a SUKYANO gram image, and save image

data to a host computer 20. The SUKYANO gram analysis means 26 analyzes SUKYANO gram image data, models the radiopacity length of analyte as three-dimension configuration data computable for every angle of rotation of every slice location of the direction of a body axis, and a scanner, and saves the data of this model (henceforth the three-dimension-radiopacity length model of analyte) to a host computer 20. The tube electric current setting means 22 determines automatically the tube electric current set point inputted from the actuation means 21, and a series of tube electric current values, i.e., the change pattern of the tube electric current, which change with time according to change of the radiopacity length of the photography part of analyte during a scan based on the data of the three-dimension-radiopacity length model of analyte. Thus, the change pattern of the determined tube electric current is saved to a host computer 20, and call appearance is carried out one by one according to the photography part of analyte at the time of this scan, and it changes the tube electric current of the X line source 12.

[0032] In this invention, X dosage irradiated by analyte 15 is beforehand calculated before this scan based on the change pattern of the tube electric current determined further above. Although the mAs value is used as an amount corresponding to usually irradiated X dosage in the X-ray plant, this count has also adopted the mAs value. This mAs value is the product of the tube electric current (mA) and irradiation time (s), and since it is proportional to total of X dosage irradiated from the X line source 12 when tube voltage is fixed (tube voltage is fixed and is used in an X-ray CT scanner in many cases), it is used as criteria of X dosage. About X dosage irradiated by the analyte 15 calculated here, it will be evaluated by the operator as a prediction exposed dose to analyte 15.

[0033] The flow chart of a series of actuation of the 1st scan operation which used the X-ray CT scanner concerning this invention for drawing 3 is shown. In this scan operation, the description is shown in three-dimension data generation of steps 103, 106, and 108, the tube electric current pattern generation of step 110, mAs count of step 111, and the mAs display of step 114. Hereafter, the detail of the 1st scan operation of drawing 3 is explained, referring to drawing 2.

[0034] In drawing 3, the SUKYANO gram image of analyte 15 is first photoed at the process of SUKYANO gram photography of step 101. The configuration which photos a fault image is fundamentally the same as the configuration which photos the SUKYANO gram image of analyte 15. At this step, without rotating a scanner 11, SUKYANO gram image data irradiates X-ray 14 from a transverse plane at analyte 15, and is obtained by incorporating detection data with a detector 13. The SUKYANO gram image obtained at this time is the thing of the direction of a transverse plane. This SUKYANO gram image data is sent to a host computer 20 from a detector 13. This SUKYANO gram image data is used for positioning of the analyte 15 at the time of this scan, and also it is used especially by this invention for the decision of the change pattern of the tube electric current for tube electric current control.

[0035] Next, at the process of the SUKYANO gram data analysis of step 102, and the process of the 1st three-dimension data generation of step 103, it is analyzed by SUKYANO gram analysis means 26 by which SUKYANO gram image data was connected to the host computer 20, and the three-dimension-radiopacity length model of analyte 15 is generated. This three-dimension-radiopacity length model is a model in which the relation between the location of analyte 15 in the case of carrying out CT photography of the analyte 15 and radiopacity length is shown. It is indicated by the application for patent No. 100501 [ 2000 to ] about the creation approach of the three-dimension-radiopacity length model of analyte 15.

[0036] Hereafter, an example of the creation approach of the three-dimension-radiopacity length model of analyte 15 is explained. Drawing in which drawing 4 shows correspondence with a SUKYANO gram image, a slice location, and the example of projection data, and drawing 5 are drawings showing the model in 1 slice location of a three-dimension-radiopacity length model. Drawing 4 (a) shows the SUKYANO gram image 29 of the analyte photoed at step 101. This SUKYANO gram image 29 makes the photography field the field from a thorax to the abdominal mid-position. A slice location is chosen from the photography fields of such a SUKYANO gram image. In illustration, the slice location of n pieces is chosen. P1, --, Pi, --, Pj, --, Pn are slice locations among drawing.

[0037] Drawing 4 (b), (c), and (d) are the explanatory views of the model decision of a three-dimension-radiopacity length model. CT tomogram for two slice locations Pi and Pj of arbitration -- like drawing 4 (b) -- \*\*\*\* -- if it assumes that it is what is, the projection data of the X-ray magnitude of attenuation of the lengthwise direction (the vertical direction of illustration) should become like drawing 4 (c) -- it comes out. Since the cross section of the truncus section of the body is usually close to an ellipse form, it is judged to be what gross errors do not have to assume CT tomogram for the slice locations Pi and Pj of arbitration by drawing 4 (b). Then, about the projection data of drawing 4 (c), it converts into radiopacity length data, it finds the integral in accordance with an axis of abscissa after that, and asks for area. At this time, in the conversion to the radiopacity length of the projection data of the X-ray magnitude of

attenuation, since it is easy, the body considers that it is equivalent to water, and changes data. Both relation is expressed with  $b = \log c / \mu_w$ , when the X-ray magnitude of attenuation is set to  $c$  and the linear attenuation coefficient of  $b$  and water is set to  $\mu_w$  for radiopacity length. Moreover, about an axis of abscissa, it changes so that the width of face of the whole field where X-ray magnitude-of-attenuation data exist may be in agreement with the width method of the body. Drawing 4 (d) is the distribution map of the radiopacity length data of the analyte 15 in the slice locations  $P_i$  and  $P_j$  changed from the projection data of drawing 4 (c). In the maximum radiopacity length in the slice locations  $P_i$  and  $P_j$ , in drawing 4 (d),  $b_i$ ,  $b_j$ , and area serve as  $S_i$  and  $S_j$ . About the radiopacity length data of drawing 4 (d), if the maximum radiopacity length  $b_i$  and  $b_j$  and area  $S_i$  and  $S_j$  are observed,  $b_i$  and  $S_i$  can consider that  $b_j$  and  $S_j$  are the values reflecting the radiopacity situation of the fault image in the slice location  $P_j$  reflecting the radiopacity situation of the fault image in the slice location  $P_i$ .

[0038] Then, it decided to make a model as a three-dimension-radiopacity length model of analyte 15 in the ellipse form 30 where the slice cross section in each slice location is shown in drawing 5. In this modeling,  $S_i$ ,  $S_j$ , and a minor axis are set to  $b_i$  and  $b_j$  for the area of the ellipse form models 30i and 30j in the slice locations  $P_i$  and  $P_j$ . Consequently, [Equation 1] since the area of the ellipse form models 30i and 30j is expressed with [a-one number] when the major axis of the ellipse form models 30i and 30j is set to  $a_i$  and  $a_j$

$$S_i = (\pi \cdot a_i \cdot b_i) / 4$$

$$S_j = (\pi \cdot a_j \cdot b_j) / 4$$

Major axes  $a_i$  and  $a_j$  are searched for with [a-two number].

[Equation 2]  

$$a_i = 4 S_i / (\pi \cdot b_i)$$

$$a_j = 4 S_j / (\pi \cdot b_j)$$

[0039] Since the ellipse form model 30 as a radiopacity length model corresponding to the fault image in each slice location was called for by the above, the three-dimension-radiopacity length model 30 can be created by arranging these ellipse form models 30 in the direction of a body axis. When the pitch of the slice location of the direction of a body axis is coarse, it asks for one or the two intermediate ellipse form models or more by interpolation with a least square method between the ellipse form models which adjoin each other, for example. Radiopacity length data  $T=T(X, Y, Z)$  of the analyte 15 in a three-dimension coordinate  $(X, Y, Z)$  system is generated as data of the three-dimension-radiopacity length model 30 of analyte 15 by the procedure like \*\*\*\*.

[0040] Next, although the change pattern of the tube electric current given to the X line source 12 using the above-mentioned three-dimension-radiopacity length model 30 will be set up at the process of step 104 to the step 110, how to search for the tube electric current which used the three-dimension-radiopacity length model 30 before that is explained. The three-dimension-radiopacity length model 30 for which it asked by drawing 4 and drawing 5 reflects the radiopacity length of the fault image in each slice location of analyte. Since the data of the three-dimension-radiopacity length model 30 are stored in the memory which once contains the register of a host computer 20, if scanning conditions, such as photographic coverage and a table pitch, are determined, the data of the model of the range will be taken out from memory, and will be used for generation of the 2nd and 3rd three-dimension data, and the decision of the change pattern of the tube electric current.

[0041] The tube electric current is determined by the tube electric current setting means 23 in each slice location based on the radiopacity length obtained from the three-dimension-radiopacity length model 30 for every scanner angle of rotation. The radiopacity length model 30 in the slice location (location of the direction of a body axis)  $Z$  is shown in drawing 6. Moreover, the tube electric current in a certain scanner angle of rotation is usually matched and determined as the maximum of the radiopacity length of the three-dimension-radiopacity length model in the scanner angle of rotation. In setting up the tube electric current, since the radiopacity length who shows this maximum is obtained with the pass which passes through the core 0 of the ellipse form model 30 of drawing 6, he should take into consideration only radiopacity Cho of pass who passes through the core 0 of this ellipse form model 30 for every scanner angle of rotation. Therefore, when a slice location is set to  $Z$  and scanner angle of rotation is set to  $\theta$  (the starting point of  $\theta$  is made into the direction of a minor axis of the ellipse form model 30) in drawing 6, the maximum radiopacity

length T in the location can express  $T=T(Z, \theta)$  as a function of Z and theta.

[0042] Since this maximum radiopacity length T (Z, theta) is the die length of the pass passing through the center position 0 of the ellipse form model 30, when a major axis is set to a and b and scanner angle of rotation are set to theta for a minor axis, he can express like [a-three number].

[Equation 3]

$$T(Z, \theta) = (a \cdot b) / \sqrt{a^2 \cos^2 \theta + b^2 \sin^2 \theta}$$

Here, a and b correspond with ai of [a-one number] and a [a-two number], aj, and bi and bj.

[0043] Next, an example of the setting approach of the tube electric current is explained. First, maximum (maximum of pass in the total slice locations P1-Pn) of the pass in all the range that scans analyte is set to Tmax, and the minimum value (similarly minimum value of pass) is set to Tmin. These values are known when making the three-dimension-radiopacity length model 30. When changing the tube electric current in the range of Maximum Imax (mA) and the minimum value Imin (mA), in this example, the maximum of the tube electric current, the minimum value and the maximum of pass, and the minimum value are made to correspond, respectively, and straight-line relation is given between the tube electric current and pass. The relation between the tube electric current I and Pass T is expressed like [a-four number].

[Equation 4]

$$I = \{(T - T_{\min})(I_{\max} - I_{\min})\} / (T_{\max} - T_{\min}) + I_{\min}$$

Here, since Pass T corresponds to T (Z, theta), the tube electric current I serves as a primary function of (Z, theta), and every slice location Z and scanner angle of rotation theta are asked for it.

[0044] Next, it returns and explains to the flow chart of drawing 3. At the process of step 104 and step 105, an operator inputs the table pitch and the scanning starting position as scanning conditions from the actuation means 21 with reference to a SUKAYANO gram image. CT photographic coverage, the slice location, and scanning angle of rotation of analyte are determined by these data. As system of coordinates at this time, like the above (Z, theta), system of coordinates are good and it is good to also input the data of scanning conditions by the data of system of coordinates (Z, theta).

[0045] Next, the data of the 2nd three-dimension-radiopacity length model are generated at the process of step 106. The data generated at this process are maximum radiopacity Cho of each slice location Z and every scanning angle of rotation theta, and since it can ask with [a-three number] from the data of the 1st three-dimension-radiopacity length model, they call and calculate the data of the 1st three-dimension-radiopacity length model from the memory of a host computer 20. This result of an operation is expressed with  $T=T(Z, \theta)$ .

[0046] Next, at the process of step 107, the scanning time amount as scanning conditions is inputted from the actuation means 21. If it is decided that scanning time amount will be a scanning starting position and a table pitch, since the location (Z, theta) of the X line source 12 under scan can be expressed as a function of the elapsed time t after scanning initiation, the 2nd three-dimension-radiopacity length model T of the analyte 15 in each scanning location, i.e., the maximum radiopacity length, can express as function  $T=T(t)$  of time amount t. For this reason, at the process of the 3rd three-dimension-radiopacity length model generation of step 108, the function of the maximum radiopacity length T is changed into  $T=T(t)$  from  $T=T(Z, \theta)$ .

[0047] Next, at the process of the tube electric current set point input of step 109, an operator inputs the set point of the tube electric current, for example, Maximum Imax and the minimum value Imin of the tube electric current under scan, from the actuation means 21. At the process of the tube electric current pattern generation of step 110, the tube electric current setting means 23 calls data [ of a three-dimension-radiopacity length model ] T (t) from a host computer 20, and determines automatically the change pattern of the tube electric current according to the photography part of analyte 15 based on the above-mentioned tube electric current set point. Although it will match with radiopacity length T (t) and the value of the tube electric current under scan will be set up at this time, when radiopacity length T (t) is min, the minimum tube electric current is set up, and when radiopacity length T (t) is max, it is determined that the change pattern of the tube electric current will set up the greatest tube electric current. Moreover, there are various things besides the primary function shown in [the-four number] as relation between radiopacity length T (t) and the value of the tube electric current (however, T of [a-four number] corresponds to T (t)).

[0048] Like the above, it carries out and the tube electric current is determined as a function of time amount  $t$  according to the three-dimension-radiopacity length model of analyte 15. Therefore, the change pattern of the tube electric current can be expressed as  $I=I(t)$ . Thus, change pattern  $I=I(t)$  of the determined tube electric current is saved to a host computer 20, and call appearance is carried out one by one according to the photography part of analyte 15 at the time of this scan, and it controls the tube electric current under scan through a high-voltage transformer assembly 22.

[0049] the example of a display of the change pattern of the tube electric current is shown in drawing 7 (the profile accompanying [ since it is easy in the example of a display of the change pattern of the following tube electric currents ] change of the scanner angle of rotation  $\theta$  also including this example -- about change of the periodic tube electric current, it omits and only change by the slice location is shown). This is displayed on the screen of a display 25 as contrasted with the SUKYANO gram image 29. By the change pattern 31 of the tube electric current, a tube electric current value (mA) is taken along an axis of ordinate, and the elapsed time  $t$  after scanning initiation is taken along the axis of abscissa. In the case of the example of a display, the tube electric current is the value of whenever [ middle ] in early stages of a scan (abdomen), serves as the minimum value in the middle (between an abdomen and thorax), and serves as maximum at the telophase (thorax). Since contrast with a tube electric current value and a photography part can be performed at a glance by juxtaposing the change pattern 31 and the SUKYANO gram image 29 of the tube electric current on the same screen like this example of a display, it is effective in decision of the validity of a tube electric current value.

[0050] Next, at the process of mAs count of step 111, X dosage irradiated by analyte 15 during a scan is calculated based on the change pattern of the tube electric current determined at step 110. Here, as criteria of X dosage irradiated by analyte 15, mAs which is the product of the tube electric current (mA) and irradiation time (s) is used like \*\*\*\*. Therefore, at this step, time amount is integrated with change pattern  $I=I(t)$  of the tube electric current, and the X dosage mAs irradiated by analyte 15 is calculated. This integral is performed by [the-five number].

[Equation 5]

$$mAs(t) = \int_0^t I(t') dt'$$

Since the mAs value calculated here is an amount equivalent to X dosage irradiated by analyte 15 to the last, it takes exact correspondence with X dosage and a mAs value, and is made to perform conversion between both by experiment etc.

[0051] It considers calculating the exposure X dosage mAs to analyte 15 by raising the change pattern 31 of the tube electric current shown in drawing 7 to an example. In this case, the change pattern 31 of the tube electric current is  $I=I(t)$ , calculating mAs by integrating with this, since it is the function of time amount will calculate the area of drawing of the change pattern 31 of the tube electric current, and the area  $S$  of drawing of the change pattern 31 of the tube electric current is equivalent to mAs.

[0052] Next, the calculated value of mAs calculated at step 111 is expressed on the screen of a display 25 as the process of a mAs calculated-value display of step 112. At step 111, since mAs corresponding to X dosage irradiated by analyte over all the fields of the scanning range of analyte 15 in the phase where the change pattern of the tube electric current was generated is calculated, an operator is shown as data for an operator to judge whether this mAs value may start a scan at this step 112.

[0053] At the process of mAs decision of step 113, an operator judges about the validity of mAs as the whole. That is, when an operator does comparison ponderation of the disadvantageous profit by the X-ray exposure to the profits and analyte 15 by CT photography performed from now on, judges whether mAs as the whole is too large and judges that mAs as the whole is too large, the set point of the tube electric current will be lowered. In this case, return and the tube electric current set point are again inputted into step 109, and the change pattern of the tube electric current is reset.

[0054] The example of the change pattern of the tube electric current is shown in drawing 8. Change pattern 31a of the tube electric current shown in drawing 8 (a) is an example in the case of being  $I_0$  with same minimum value ( $I_{min}$ ) and maximum ( $I_{max}$ ) of the tube electric current in the case of usual tube electric current regularity ( $I_0$ ). In the graph of change pattern 31a of the tube electric current of drawing 8 (a), mAs is area  $S_a$ . Next, in change pattern 31b of the tube electric current drawing 8 (b) Shown, the tube electric current is the  $I_0$  [ same in early stages ] as drawing 8 (a), in the middle, serves as the low minimum value  $I_{min}$ , and serves as the maximum  $I_{max}$  higher than  $I_0$  from  $I_0$  at the telophase. Although mAs in the graph of change pattern 31a of the tube electric current of drawing 8 (b) is area  $S_b$ , this area  $S_b$  is

smaller than the area  $S_a$  of drawing 8 (a), and is reducing the exposed dose of analyte 15.

[0055] In change pattern 31c of the tube electric current shown in drawing 8 (c), compared with the graph of drawing 8 (b), maximum  $I_{max}$  of a telophase is made small and suppose that it is almost the same as  $I_0$ . In this case, the tube electric current is suppressed by the low eye as the whole scan. Although mAs in the graph of change pattern 31c of the tube electric current of drawing 8 (c) is area  $S_c$ , this area  $S_c$  is still smaller than the area  $S_b$  of drawing 8 (b), and is reducing the exposed dose of analyte 15 further.

[0056] Compared with drawing 8 (b), the middle minimum value  $I_{min}$  is made still smaller, and it is made for  $I_{min}$  to fall sharply to  $I_0$  in change pattern 31d of the tube electric current shown in drawing 8 (d). Although change pattern 31d [ of the tube electric current of drawing 8 (d) ] mAs is area  $S_d$ , it is still smaller than the area  $S_c$  of drawing 8 (c).

[0057] When the maximum of the tube electric current set point is lowered like the case of drawing 8 (c), a part with the thick thickness of analyte 15, i.e., radioparency Cho, will reduce the tube electric current in a large part. Therefore, change pattern 31c of the tube electric current of drawing 8 (c) thinks the image quality in the part of a low consistency as important like especially lungs, and it is suitable to reduce the exposed dose in the field of high density like an abdomen.

[0058] When the minimum value of the tube electric current set point is lowered like the case of drawing 8 (d), a part with the thin thickness of analyte 15, i.e., radioparency Cho, will reduce the tube electric current in a small part. Therefore, the image quality in the part of high density is thought as important like the bone circumference or the real section, and it is especially suitable change pattern 31d of the tube electric current of drawing 8 (d) to reduce the exposed dose in the field of a low consistency.

[0059] In drawing 8 (c) and drawing 8 (d), although either the maximum  $I_{max}$  of the tube electric current set point or the minimum value  $I_{min}$  is made small, it is also possible to make both small and to reduce an exposed dose on the average about all the fields of analyte 15. About the change pattern of the tube electric current newly set up like the above, in calculating mAs again and being satisfactory, it adopts as it is.

[0060] Next, in the process of a scan of step 114, an operator performs a scan on scanning conditions including the change pattern of the tube electric current determined above.

[0061] Next, at the process of a mAs addition value display of step 115, according to the above-mentioned [-five number], the addition value of mAs under scan is calculated serially, it expresses on the screen of a display 25 as real time, and an operator is shown. The approach of displaying the relative value as a ratio to the mAs value as the whole as the mAs addition value method of presentation or the approach of displaying the absolute value of a mAs addition value can be chosen. Of course, it is also possible to display the both on coincidence.

[0062] Next, the 2nd example of scan operation of the X-ray CT scanner concerning this invention is explained. Drawing 9 shows the flow chart of a series of actuation of the 2nd example of scan operation. The process of count of the dose distribution in analyte 15 and a display is added, and an operator also looks at the dose distribution in analyte 15, and enables it to make a judgment of scanning activation to the flow chart of the 1st example of scan operation of drawing 3 in this example of scan operation after the process of mAs count of step 111, and a mAs display of step 112. For this reason, explanation of this example of actuation explains the process of count of the dose distribution in the analyte 15 of steps 201-205, and a display to importance.

[0063] Hereafter, although step 205 is explained from step 201 in the 2nd example of scan operation of drawing 9, before starting contents explanation of a step, the example of a display of the count result of the dose distribution in analyte 15 is shown in drawing 10. Drawing 10 (a) is the example of a display of the dose distribution in the cross section 35 of analyte, and drawing 10 (b) is the example of a display of the dose distribution in the side face 36 of the direction of a body axis of analyte. Both drawings carry out distribution dosage in analyte 15 etc., and are, and isodose lines 38a-38c, and 39a-39c are shown, and it has a high dose, so that it is close to a body surface. In this example of actuation, since an operator is shown the dose distribution of analyte 15, an operator becomes the description with the ability of more detailed evaluation about the X-ray exposure of analyte to be performed [ big ].

[0064] In this example of actuation, before calculating the dose distribution in analyte at step 203, as preparation, the CT valve model of analyte is generated at step 201,  $\mu$  model of analyte is generated at step 202, and the dose distribution in analyte is calculated by after that based on  $\mu$  model data of analyte, and X dosage data irradiated by analyte.

[0065] first, at the process of analyte CT valve model generation of step 201 CT value distribution model (henceforth standard body CT valve model) data of the standard body are acquired beforehand. By saving for the storage means of a host computer 20, and amending based on the data of the SUKAYANO gram image of the analyte 15 which acquired this

standard body CT valve model data at step 101 The CT valve model (henceforth an analyte CT valve model) of analyte 15 is created. The three-dimension-CT value distribution data obtained from the fault image which carried out CT photography of the standard human phantom etc. as the above-mentioned standard body CT valve model data, for example are used. Since a fault image expresses distribution of a CT valve and distribution of the linear attenuation coefficient to the X-ray of effective energy (usually 60 keV(s)) is expressed, the three-dimension-CT value distribution data which reconfigured to the three dimension are data of the three-dimension-spatial distribution of a linear attenuation coefficient, and can use this fault image for count of the amount of decrease of the X-ray irradiated by analyte.

[0066] Next, an example of the generation method of an analyte CT valve model is explained using drawing 11. In this example, the analyte CT valve model data which express the three-dimension-CT value distribution of analyte 15 with step 101 from the SUKYANO gram image data which photoed, acquired and surveyed analyte 15, and the above-mentioned standard body CT valve model data are generated. In generation of this analyte CT valve model, the SUKYANO gram image data of analyte 15 and the SUKYANO gram image data of the standard body are used as a medium.

[0067] Drawing 11 is drawing for explaining the creation procedure of the analyte CT valve model of step 201. In drawing 11 (a), in drawing 11, drawing 11 (c) shows the example of the analyte CT valve model data 44 with which drawing 11 (d) searched for the example of the SUKYANO gram image data 43 of an observation of analyte for the example of the SUKYANO gram image data 42 of the standard body with which drawing 11 (b) searched for the example of the standard body CT valve model data 41 by count from the standard body CT valve model data 41 of drawing 11 (a) by count. The standard body CT valve model data 41 of drawing 11 (a) are CT value distribution model of the truncus section of the standard bodies, such as a human phantom, and show CT value distribution model of the cross section for every slice location from a shoulder to an abdomen.

[0068] Since a SUKYANO gram image is generable from the three-dimension-CT value distribution model with count, the standard body SUKYANO gram image data 42 of drawing 11 (b) is obtained by asking for the data projected from the transverse plane about the standard body CT valve model data 41 of drawing 11 (a). The observation SUKYANO gram image data 43 of the analyte of drawing 11 (c) is SUKYANO gram image data which photoed the field same about the truncus section of analyte 15 as the standard body SUKYANO gram image data 42 from the transverse plane. About this image, it will be called an analyte SUKYANO gram image below.

[0069] In drawing 11, although it has indicated that the standard body SUKYANO gram image data 42 of the truncus section and the analyte SUKYANO gram image data 43 can be juxtaposed and contrasted, both usually differ also from a dimension and a CT valve. For this reason, contrasting the standard body SUKYANO gram image data 42 and the analyte SUKYANO gram image data 43, based on the difference among both, a part in agreement presupposes that it remains as it is, is made to deform about a different part, it amends the standard body CT valve model data 41 so that analyte 15 may be suited, and it generates the analyte CT valve model data 44.

[0070] In the example of the truncus section of drawing 11, it is first related in the direction of a body axis. Die-length A from the shoulder of the standard body SUKYANO gram image data 42 and the analyte SUKYANO gram image data 43 to a diaphragm, It divides into die-length B from a diaphragm to an intestinal tract, and CT value distribution of the direction of a body axis of the standard body CT valve model data 41 is made to approximate the standard body CT valve model data 41 to the actual condition of analyte 15 by interpolation and elongating, or being thinned out and shortened based on each difference. About a longitudinal direction, it divides into the left and the right on the basis of a body axis, breadth on either side is similarly, amended based on each difference, and the actual condition of analyte 15 is made to resemble. About a cross direction, the data of the cross direction of the standard body CT valve model data 41 are interpolated to linearity based on radioparency Cho of the cross direction presumed from the analyte SUKYANO gram image data 43. Thus, the analyte CT valve model data 44 are generated based on two SUKYANO gram image data 42 and 43 by setting the standard body CT valve model data 41 by the actual analyte 15.

[0071] Next, at the process of analyte mu model generation of step 202, the CT valve of the analyte CT valve model data 44 generated at step 201 is changed into a linear attenuation coefficient mu, and the three-dimension-mu value distribution model of analyte 15 is generated. Conversion to a linear attenuation coefficient mu is performed as following from a CT valve.

[0072] A CT valve is determined by the linear attenuation coefficient to the X-ray of effective energy (60keV(s) are usually used), and is defined as water =0, air =1000, and average bone =1000. When the CT valve in the location X of an

analyte CT valve model is now set to CTX, linear attenuation coefficient  $\mu_X$  in the effective energy (60keV) in the location X is expressed with [a-six number] and [a-seven number].

[Equation 6]

$$\mu_x = CT_x (\mu_w - \mu_{air}) / 1000 + \mu_w \quad (\text{ただし、} CT_x \leq 0.0)$$

[Equation 7]

$$\mu_x = CT_x (\mu_{bone} - \mu_w) / 1000 + \mu_w \quad (\text{ただし、} CT_x > 0.0)$$

Here,  $\mu_w$  is [ the linear attenuation coefficient (=0.00025cm<sup>-1</sup>) of air and  $\mu_{bone}$  of the line source weak multiplier (=0.206cm<sup>-1</sup>) of water and  $\mu_{air}$  ] bony linear attenuation coefficients (in the case of =0.567cm<sup>-1</sup>, however consistency 1.8 g/cm<sup>3</sup>).

[0073] Next, at the process of dose distribution count of step 203, as shown in drawing 12, the dose distribution in analyte 15 (drawing 12 (c)) is calculated using the data (drawing 12 (a)) of X dosage irradiated by the analyte for which it asked at step 111, and the analyte mu model data 45 (drawing 12 (b)) for which it asked at step 202. In count of this step 203, in consideration of the ENERUGI spectrum of the X-ray irradiated by analyte, attenuation of the X-ray within analyte 15 is calculated, and the spatial distribution of the dosage in analyte 15 is calculated. The amount of decrease of the X-ray at the time of irradiating an X-ray from the direction of arbitration at analyte 15 is analytically computable by using the analyte mu model data which are the model of the three-dimension-linear attenuation coefficient ( $\mu$ ) of analyte, and the field of others [ technique / such / count ] already, for example, fields, such as a radiation therapy planning apparatus, is performed (bibliography 1, \*\*\*\* Seiya, a radiotherapy planning system, P.90-92, P.113-115, the Shinohara publication, April [ Heisei ] issue [ 20 day ]).

[0074] In count of attenuation of an X-ray, the effective distance delta which an X-ray penetrates toward the X line source 12 first from the location X observed in analyte 15 is calculated. Effective distance is defined as 1 in the distance decreased to 1/e by the medium which an X-ray penetrates. When not taking the energy spectrum of an X-ray into consideration, when the medium of presentation i is [ those with  $d_i$  (cm) and the linear attenuation coefficient of presentation i ]  $\mu_i$  (cm<sup>-1</sup>) in real distance, the effective distance delta is expressed with [a-eight number] by the X line source 12 from the attention location X.

[Equation 8]

$$\delta = \sum_i \mu_i \cdot d_i$$

[0075] However, if the energy spectrum of an X-ray is taken into consideration, effective distance will serve as a different value according to the energy of an X-ray. When the linear attenuation coefficient to the energy j of the X-ray of presentation i is set to  $\mu_{ij}$  (cm<sup>-1</sup>), effective distance  $\delta_{ij}$  to the energy j of an X-ray is expressed with [a-nine number].

[Equation 9]

$$\delta_j = \sum_i \mu_{ij} \cdot d_i$$

Here, the number [ as opposed to the X-ray of the energy j of presentation i in  $\mu_{ij}$  ] of line decrease systems (cm<sup>-1</sup>) and  $d_i$  are the transparency distance (cm) of the X-ray under presentation i. It is necessary to ask from mu value model of analyte 15 about  $\mu_{ij}$  according to the energy j of an X-ray.

[0076] Next, the dosage in the attention location X in analyte 15 is calculated. Dosage [ in / for the distance from the X line source 12 to the attention location X /  $r_x$  (m) and the distance of 1m ] is set to  $I_0$  (C/kg: C is a coulomb). About  $I_0$ , it asks experimentally, for example. When the energy spectrum of an X-ray, i.e., the component ratio of Energy j, is set to  $S_j$ , the dosage  $I_x$  (C/kg) in the attention location X is expressed with [a-ten number].

[Equation 10]

$$I_x = \sum_j S_j I_0 \exp(-\delta_j) / r_x^2 \quad (\text{単位 : C / kg})$$

Here,  $I_0$  is [ the distance from the X line source 12 to the attention location X and Units m and  $S_j$  of dosage (dosage of

the air in the unit distance from the X line source 12, unit C/kg) and rx ] the energy spectra of an X-ray.

[0077] The arbitration in the analyte 15 in the case of being in the location Q with the X line source 12 (Z, theta) is asked for the dosage in a location X as a result of count by [the-ten number]. The dosage in the location X of the arbitration at the time of rotating the X line source 12 one time rotates the location Q of the X line source 12 (Z, theta) around analyte 15, and is obtained by integrating the above-mentioned dosage by one rotation ( $\theta=0-2\pi$ ). The dose distribution in the analyte 15 in the slice location Z can be searched for by performing count in each location where it was set up in analyte 15 in the procedure like the above. Moreover, since the dose distribution in other slice locations can be similarly searched for by count, the three-dimension-dose distribution in analyte 15 is acquired by advancing count of all the fields of a photography part about the direction of a body axis of analyte 15.

[0078] When photoing the fault image of 1 slice (in the case of two-dimensional), distribution of the dosage in analyte 15 is searched for with a sufficient precision by the above-mentioned count, but if it does not take photography of scattered X-rays into consideration in performing CT photography of two or more slices during one scan (in the case of a three dimension), there is a possibility that count precision may fall. What is necessary is to take only Compton (Compton) dispersion into consideration as scattered radiation in an X-ray CT scanner, since the energy of an X-ray is the order of 100 or less keVs (bibliography 1 reference). By taking this Compton scattering into consideration, count precision can be made higher.

[0079] The three-dimension-dose distribution of the calculated analyte 15 is acquired by calculating the dosage in each set point in each slice location in analyte 15 in the procedure like the above. The count result of the dose distribution of this analyte 15 is temporarily saved to a host computer 20, and is displayed by \*\*\*\* legible for an operator etc., for example, \*\*\*\* as shown in drawing 10.

[0080] Next, the count result of step 203 is expressed to a display 25 as the process of a dose distribution display of step 204. As an example of a display in this example, the dose distribution in the tomographic layer 35 of the analyte 15 as shown in drawing 10 (drawing 10 (a)), or the dose distribution (drawing 10 (b)) of the side face 36 of analyte 15 is raised. Since a dosage line -- the organ and dose distribution of analyte 15 are shown -- is displayed in piles and the exposed dose to each organ can be recognized at a glance, when evaluating the X-ray exposure to analyte 15, it is effective in these drawings.

[0081] next, at the process of exposed dose decision of step 205 An operator looks at the count result of the dose distribution in the analyte 15 displayed at step 204. It judges whether there is any possibility that the X-ray exposure to the organ in analyte 15 may become superfluous. When it is judged as Yes, it will progress to the process of scanning activation of step 114, a scan will be started, and when it is judged as No, reinput of return and the tube electric current set point and re-evaluation of a tube electric current pattern will be carried out to the process of the tube electric current set point input of step 109.

[0082] Moreover, the approach of using CT photography data of the same analyte 15 photoed in the past in addition to the approach using the above-mentioned standard body CT valve model data as a generation method of the CT valve model data of the analyte 15 in step 201 can also be enforced. In this case, in order to actually use CT value distribution data of the same analyte 15, there is an advantage that the procedure which amends the configuration of the standard body CT valve model data 41 becomes unnecessary. However, since it is not suitable for first-time CT photography, the case where CT photography of the 2nd henceforth is performed about the analyte which performed CT photography in the past is applicable.

[0083] As described above, an operator becomes possible [ getting to know the dose distribution of the inside of the body of the analyte according to the photography technique in approximation beforehand ] by carrying out simulation count of the dose distribution of the inside of the body of analyte 15 in front of CAT, and displaying, as a count result is shown in drawing 10.

[0084] A detailed setup of as a result, for example, extent which can be satisfied with a comparatively low organization conversely radiosensitivity [ , such as a fat and muscles ] of image quality, maintaining the level of an exposed dose is attained by reducing an exposed dose uniformly about not all the organizations of analyte simply, but reducing an exposed dose, especially concerning radiosensitivity high organizations, such as bone marrow and lungs.

[0085] Next, the example of edit of the change pattern of the tube electric current which carries out CT photography of the analyte is explained using drawing 13. Drawing 13 superimposes and displays the change pattern of the tube electric current on the SUKYANO gram image of analyte. In drawing 12, the thing of the truncus section and the change pattern of the tube electric current of SUKYANO gram image data 29a are change pattern 46a of the tube electric current of the

first stage before edit, and change pattern 46b of the tube electric current by which it was corrected after edit.

[0086] At the edit process of the change pattern of this tube electric current, referring to SUKYANO gram image data 29a to change pattern 46a of the tube electric current set as the first stage displayed on SUKYANO gram image 29a in the screen of a display 25, with reference to the quantity-of-radiation distribution inside analyte 15, correction is added depending on the case and change pattern 46b of the new tube electric current is edited with the actuation means 21. The change pattern of the tube electric current of the part of arbitration is reset by this editing operation.

[0087] In this editing operation, although the tube electric current is set as an average value in the field in which a consistency changes a lot like [ near a diaphragm ] in a setup of the automatic change pattern of the tube electric current, the tube electric current is partially set up highly in the field which needs to raise image quality even if an exposed dose increases. If scanning conditions are set up like the above, since the change pattern of the tube electric current will become the function of time amount t, the value of the tube electric current of arbitration time of day can be changed. In the example of drawing 13, to change pattern 46a of the early tube electric current, a little tube electric current of the field of lungs is reduced, and it is editing into change pattern 46b of the tube electric current after correction by making a little tube electric current of the field of a diaphragm increase.

[0088] Drawing 14 is drawing having shown the relation between the tube electric current and the thickness (equivalent to radiopacity Cho) of analyte. Although explanation of the process of the above-mentioned step 110 explained as what the maximum of the tube electric current, the minimum value, and the maximum of the thickness of analyte and the minimum value are made in agreement, and has linear relation among both, about both relation, it is possible to have nonlinear relation by setup of an operator. The relation between the tube electric current I shown in drawing 14 and thickness T of analyte is expressed with [a-11 number].

[Equation 11]

$$I - I_{\min} = K (T - T_{\min})^{\gamma}$$

$$\text{ただし、} K = (I_{\max} - I_{\min}) / (T_{\max} - T_{\min})^{\gamma}$$

Here, I<sub>max</sub> and I<sub>min</sub> are [ the maximum of the thickness of analyte, the minimum value, and gamma of the maximum of the tube electric current, the minimum value, T<sub>max</sub> and T<sub>min</sub> ] constants. About gamma, it will be called gamma below.

[0089] In drawing 14, the relation between the tube electric current and the thickness of analyte is linearity in the case of gamma =1, and, in the case of gamma <1, both the relation between the tube electric current and the thickness of analyte of a graph 52 is [ a graph 51 ] nonlinear [ a graph 50 ] at the case of gamma >1. Since the relation between the tube electric current and the thickness of analyte is uniquely decided by deciding the value of gamma in the case of drawing 14, an operator can change the relation between the tube electric current I and thickness T of analyte like drawing 14 by inputting the value of gamma from the actuation means 21 by building relational expression like [a-11 number] into equipment. Moreover, in actual actuation, the maximum of the tube electric current, the minimum value and the maximum of the thickness of analyte, and the minimum value can be made in agreement, it can decide to give linear relation, and nonlinear relation can be given in inputting gamma by setup of an operator at initial setting to which an operator does not do a special setup, for example. In drawing 14, when based on gamma =1, it is regarded as the case where exposure reduction of analyte is thought as important, at the time of gamma >1, and is regarded as the case where image quality is thought as important, at the time of gamma <1.

[0090]

[Effect of the Invention] As explained above, in the X-ray CT scanner of this invention A SUKYANO gram analysis means to generate the three-dimension-radiopacity length model of analyte from the SUKYANO gram image data of an actuation means or analyte which sets up the scanning conditions of equipment, A tube electric current setting means to set up automatically the change pattern of the tube electric current according to the photography part of analyte from scanning conditions and the three-dimension-radiopacity length model of analyte, Calculate the dosage irradiated by analyte based on the change pattern of the tube electric current, and since it has a dose calculation means to display etc. By inputting the maximum of the tube electric current, and the minimum value as scanning conditions, the change pattern of the tube electric current under scan can be set up automatically, and the X-ray exposure to analyte can also be evaluated. Furthermore, when there is a possibility that the X-ray exposure to analyte may become superfluous, it is also possible to reset the change pattern of the tube electric current.

[0091] Moreover, in the X-ray CT scanner of this invention, since it has a dose distribution count means to calculate and display the dose distribution of the inside of the body of analyte, based on the change pattern of the tube electric current under scan, and the three-dimension CT valve model data of the analyte generated beforehand, the dose distribution in the inside of the body of the analyte by CT photography can be known beforehand, and the propriety of scanning activation can be judged in consideration of extent of an X-ray exposure of the organ to observe.

[0092] Moreover, since it has an analyte CT valve model generation means to generate the three-dimension CT valve model data of the above-mentioned analyte in the X-ray CT scanner of this invention based on the standard body CT valve model data and the SUKYANO gram image data of analyte which carried out CT photography and acquired the human phantom etc., generation of analyte CT valve model data is possible also about the analyte which has not carried out CT photography before only by acquisition of 1 time of the SUKYANO gram image data as preliminary photography.

[0093] Moreover, in the X-ray CT scanner of this invention, about the SUKYANO gram image of analyte, and the change pattern of the tube electric current, since it is displaying in piles, while an operator etc. looks at the photography part of analyte, it becomes possible a juxtaposition or to edit the change pattern of the tube electric current at the same screen of a display means, and the tube electric current suitable for a photography part can be set up easily.

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[Translation done.]

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CLAIMS

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[Claim(s)]

[Claim 1] X line source which carries out exposure of the X-ray while rotating the perimeter of analyte, and the X-ray detector of the many channels which detect X dosage which countered with X line source, has been arranged on both sides of analyte, and penetrated analyte, In the X-ray CT scanner possessing an image reconstruction means to reconfigure the tomogram for analyte based on X dosage data which penetrated analyte, and a display means to display a tomogram An actuation means to set up the scanning conditions of equipment, and a SUKYANO gram analysis means to analyze the SUKYANO gram image data of analyte and to generate the three-dimension-radioparency length model of analyte, A tube electric current setting means to set up automatically the change pattern of an X-ray tube current (it is hereafter called the tube electric current for short) according to the photography part of analyte based on the three-dimension-radioparency length model and the scanning conditions of said analyte, The X-ray CT scanner characterized by providing a dose calculation means to calculate the dosage irradiated by analyte based on the change pattern of said tube electric current, and to display a count result.

[Claim 2] The X-ray CT scanner characterized by providing a dose distribution count means to calculate the dose distribution of the inside of the body of analyte, and to display a count result in an X-ray CT scanner according to claim 1 based on the change pattern of said tube electric current, and the three-dimension CT valve model of analyte for which it asked beforehand.

[Claim 3] The X-ray CT scanner characterized by what the change pattern of the tube electric current and the SUKYANO gram image of analyte are juxtaposed on the same screen of said display means, or is displayed in piles in an X-ray CT scanner claim 1 and given in two.

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[Translation done.]

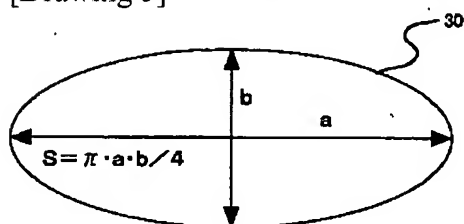
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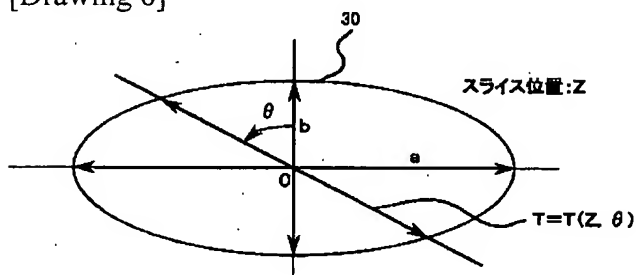
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## DRAWINGS

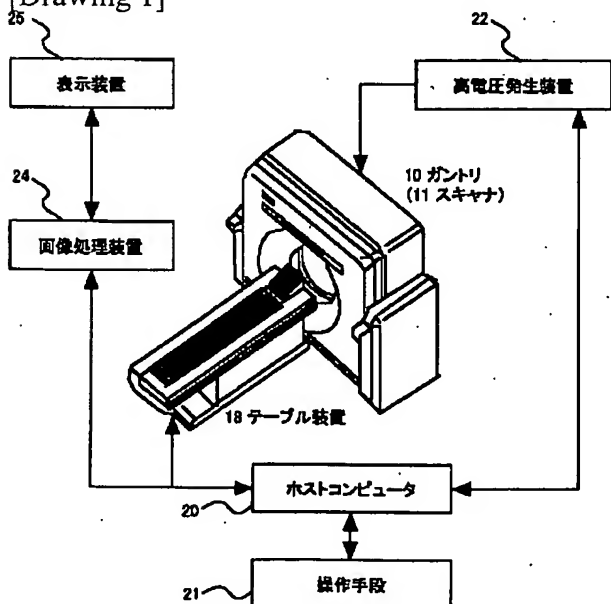
[Drawing 5]



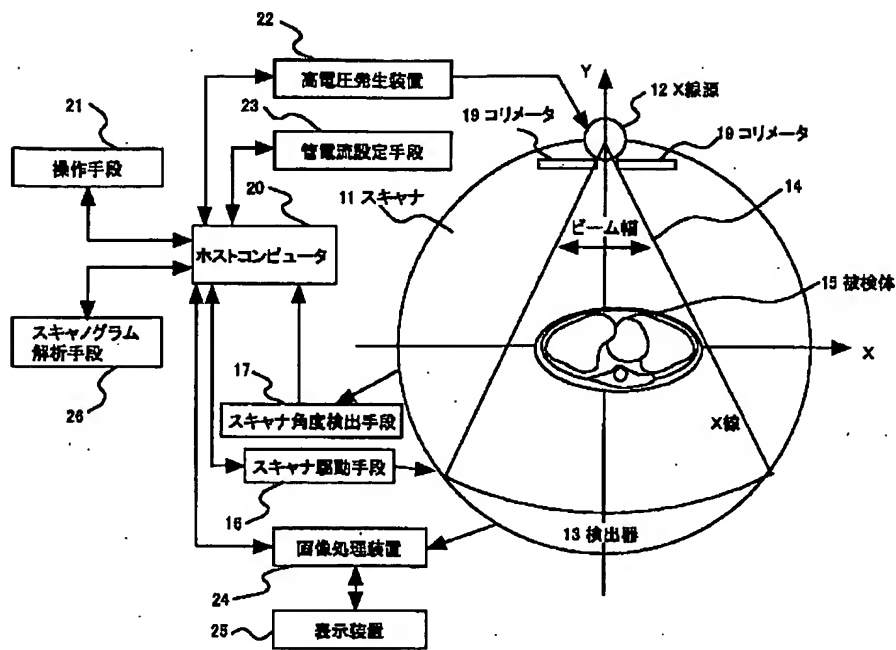
[Drawing 6]



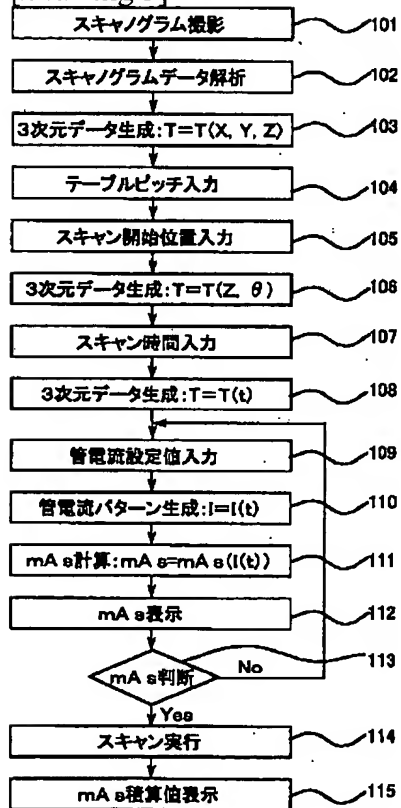
[Drawing 1]



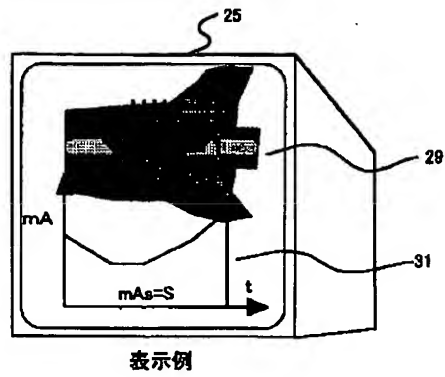
[Drawing 2]



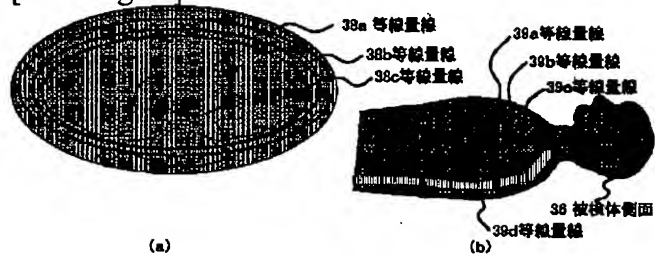
[Drawing 3]



[Drawing 7]



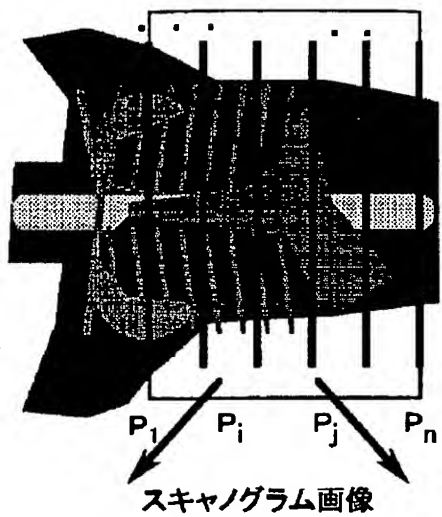
[Drawing 10]



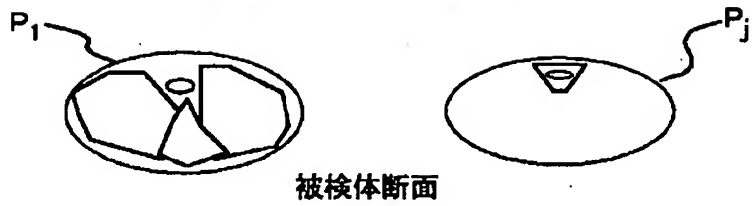
[Drawing 4]

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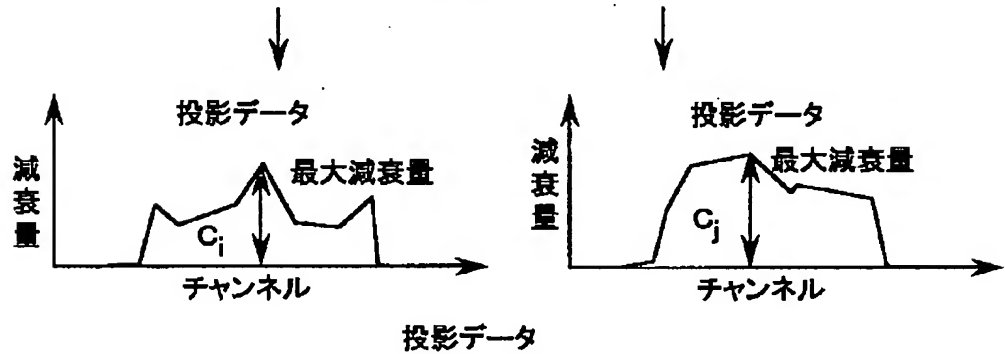
(a)



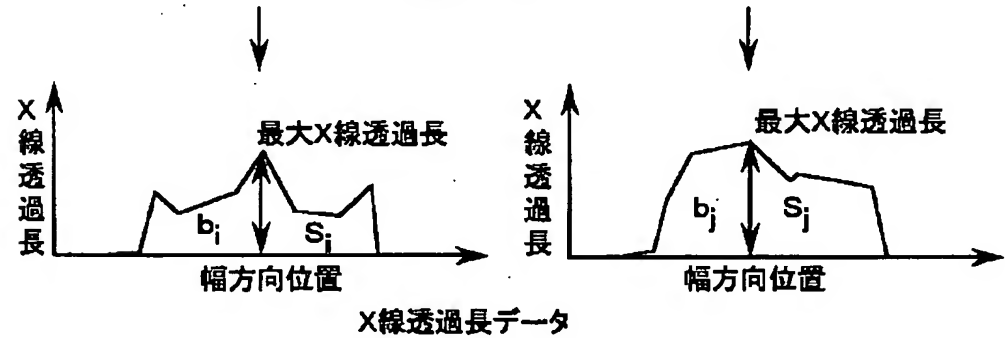
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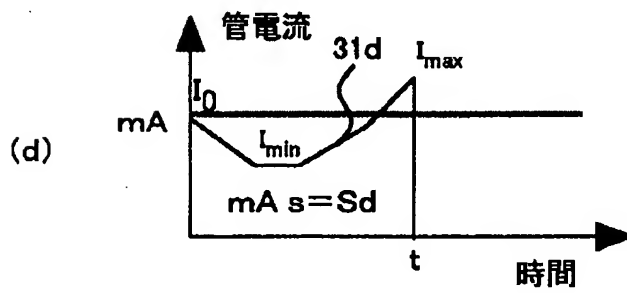
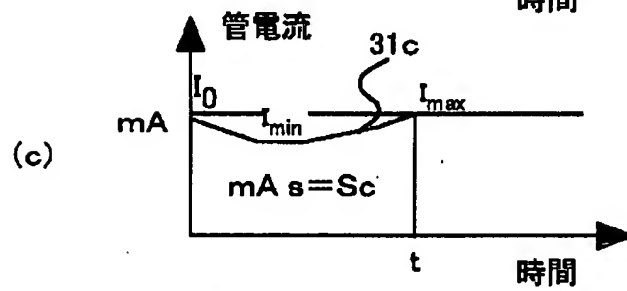
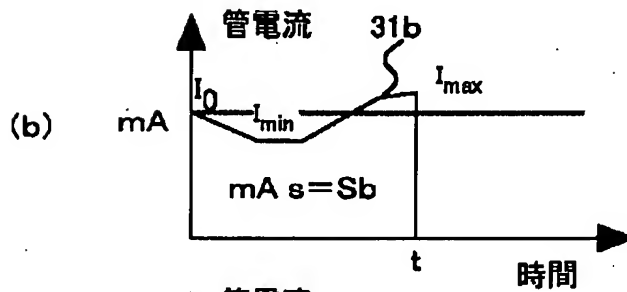
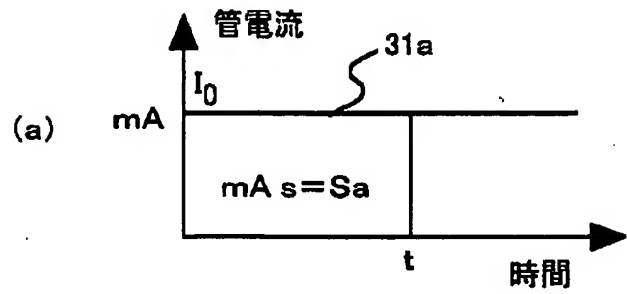
(c)



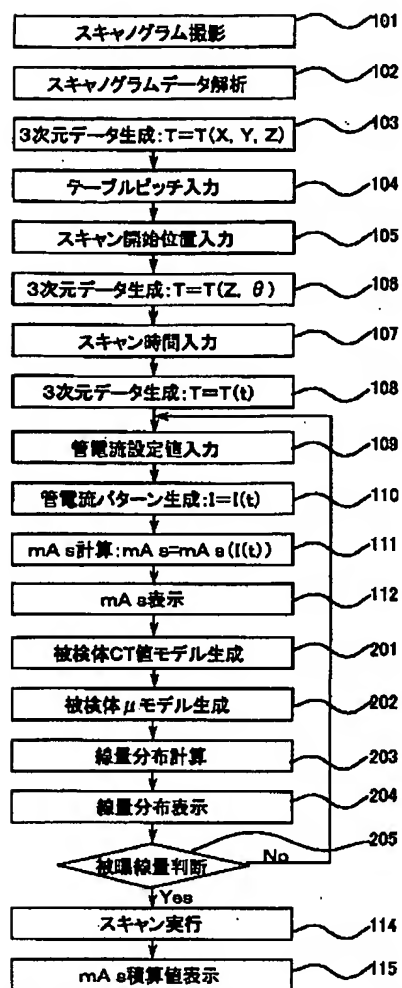
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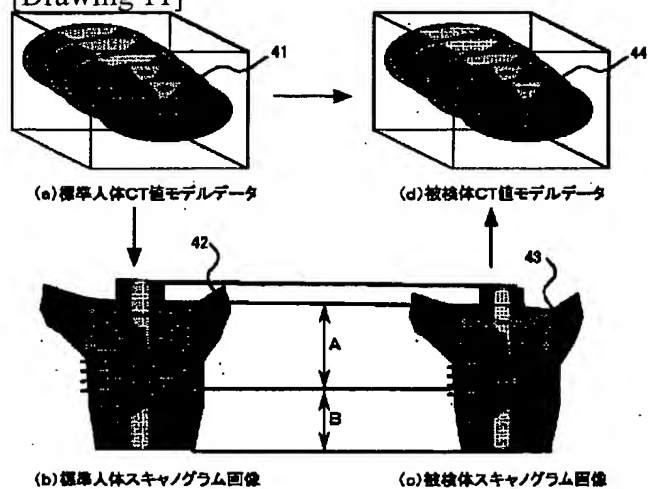
[Drawing 8]



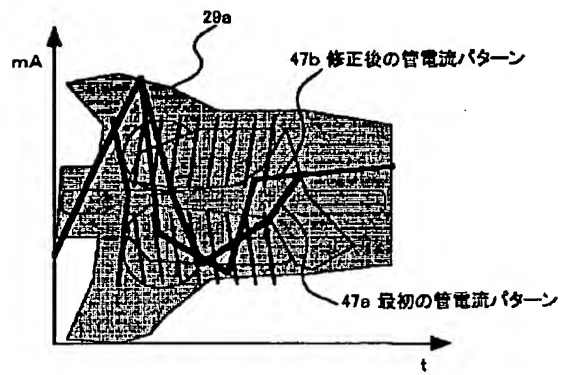
[Drawing 9]



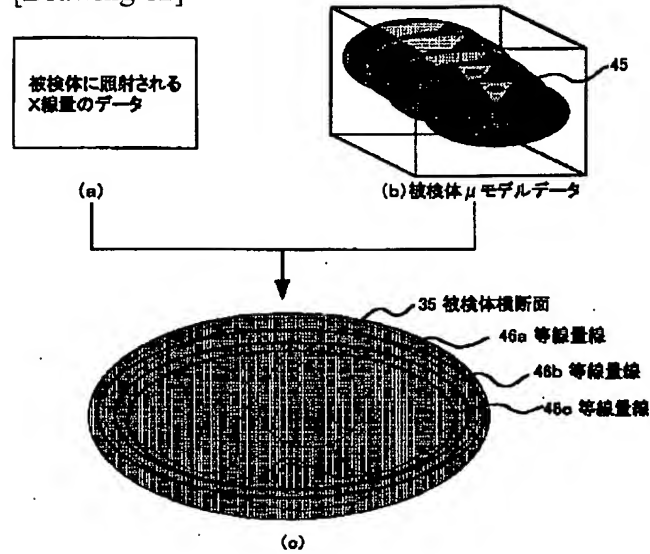
[Drawing 11]



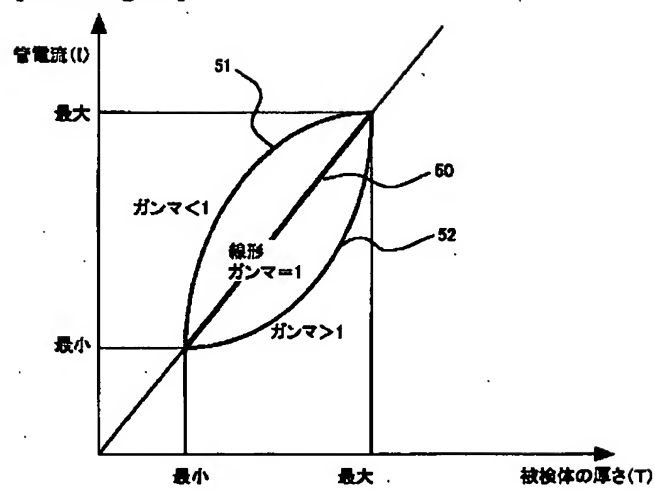
[Drawing 13]



[Drawing 12]



[Drawing 14]



[Translation done.]